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A Fair Taut-Line Mooring;
Film Recording Deep Sea Compass/inclinometer; and
A Component-structured Semispar Buoy System

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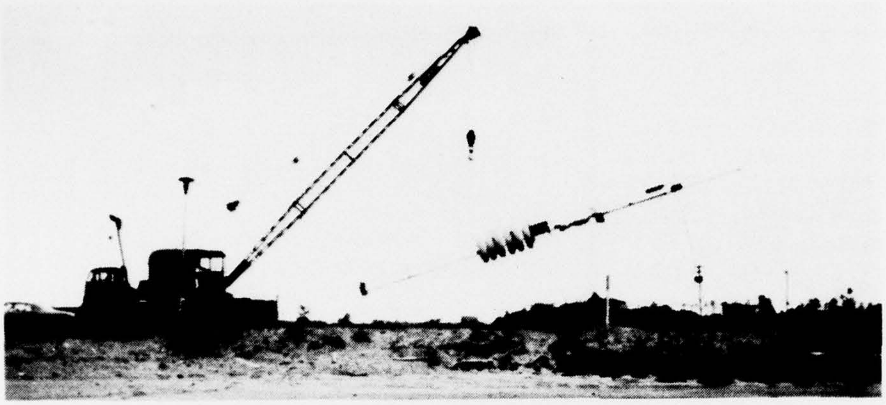

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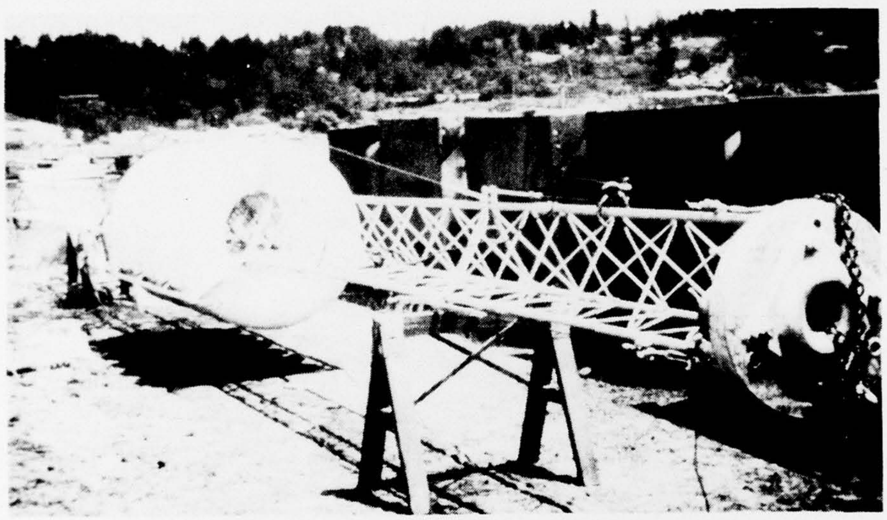

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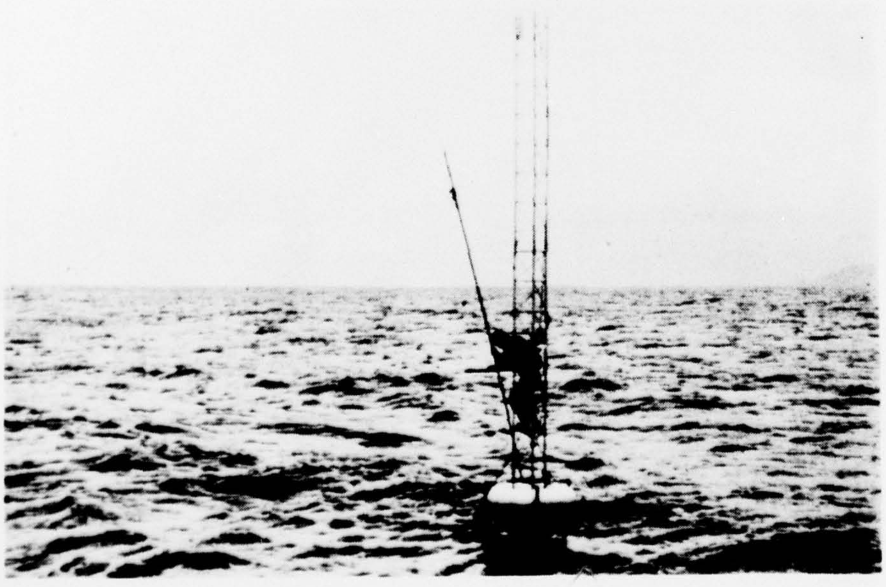

Figure 4.

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a winching-down system mounted above the waterline on the upper tower section. During the data recording period, the buoy was normally winched down until the top toroid was below the trough of the waves. At other times, it was not left in this position because of the potential for wave damage to the fragile meteorological sensors.

While the buoy was used in the drifting mode, the bellmouth section was ballasted with 1000 lb of lead. As seen in Figure 4, the buoy can be mounted by personnel for attaching or checking sensors.

FOR FURTHER INFORMATION: CONTACT

Roderick Mesecar
Technical Planning and
Development Group
School of Oceanography
Oregon State University
Corvallis, Oregon 97331

Telephone: (503) 754-2206

Rod Mesecar is head of the Technical Planning and Development Group, School of Oceanography at Oregon State University. He has B.S., M.S., and E.E. degrees in electrical engineering and a Ph.D. in physical oceanography from OSU. Since 1965, his interest has been in applying engineering technology to all disciplines of oceanography.

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FIRST CLASS MAIL

Dr. Rod Mesecar, Editor
EXPOSURE
School of Oceanography
Oregon State University
Corvallis, Oregon 97331

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A Faired Taut-Line Mooring

Due to the strong near-surface currents found along the Equator in all oceans, traditional taut-line surface moorings have not been used successfully in the past. Large hydrodynamic drag forces on cable and instruments may produce excessive tensions in the line which can cause undertow of the surface float or mechanical failure in the mooring.

In response to the desire to gather physical oceanographic data along the Equator, a mooring designated EQUA-1 was designed and successfully moored for 36 days in the Central Equatorial Pacific. The mooring was essentially a traditional taut-line system with wire rope through the fish-bite zone, compliant synthetic line below, and backup flotation near the bottom. In-line instruments were placed as shown in Figure 1. A principal element of the design was a cable fairing used in the area of the strongest currents.

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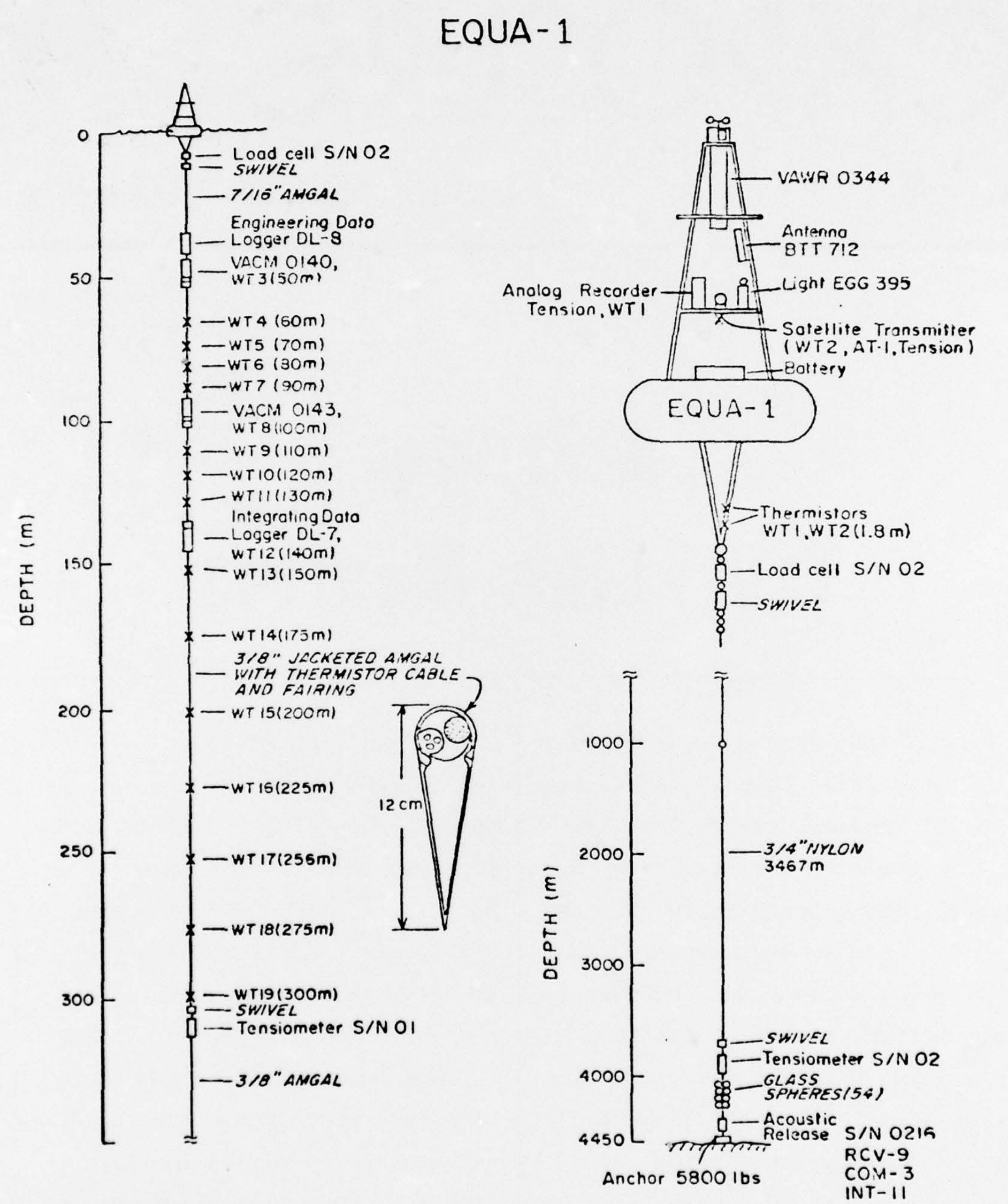


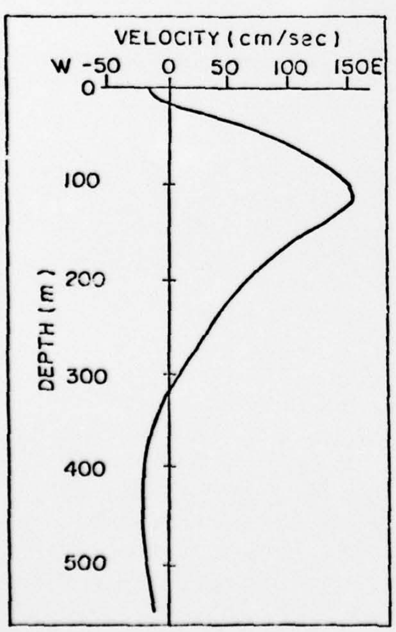
Figure 1. Schematic diagram of EQUA-1

Static modeling of the proposed mooring was used to determine the maximum tolerable drag coefficient (C_D) of various sections of cable. It was thus determined that, with the design current profile (Figure 2), a $C_D = 0.4$ in the upper 300 meters of the mooring cable would maintain the line tension at an acceptable level (Figure 3). This cable section was comprised of 3/8" 3 x 19 torque balanced Amgal® polyethelene jacketed wire and a 14-conductor thermistor cable with breakouts.

In order to reduce the hydrodynamic drag of this cable from a typical $C_D = 1.6$ to 1.8 for a bare cable, several different fairing configurations were given consideration. Eventually, Rigstrand® fairing from Fathom Oceanology was found to be capable of meeting the unique requirements that were generated by the constraints of the mooring. A neoprene extrusion was made to join the wire rope and thermistor cable into a cylindrical section as shown in Figure 4. The cables and extrusion were made up as the mooring was being deployed and each fairing piece was manually spread open and slipped over the cable. PVC ring clamps and Panduit fasteners were used (see Figure 4) at cable terminations and thermistor breakouts to restrain the fairings from longitudinal motion along the cable.

Upon recovery, the cable and fairings showed no signs of deterioration and tension records indicate that the fairings performed as predicted. I feel the drag coefficient actually

Figure 2.



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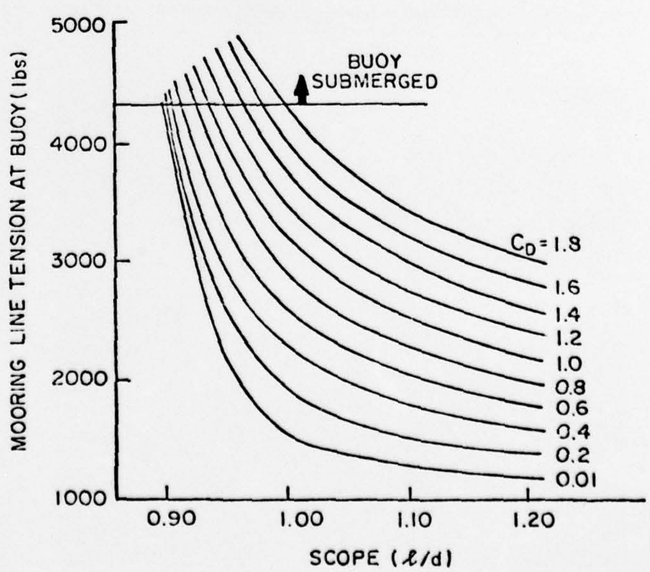


realized was around 0.3 to 0.5, although the manufacturer claims 0.15. (This lower value might be attainable under different conditions.) Future experiments are being planned to further evaluate the effectiveness of these fairings on other moorings.

An obvious additional benefit to be realized in a mooring such as this is the large reduction of strumming and vibration by the use of the fairing in strong currents. This ultimately reduces fatigue and improves the likelihood of extended mooring life. Also, an efficient fairing of this nature should be considered for station-keeping moorings in deep water, where a small watch circle is desirable but often difficult to attain.

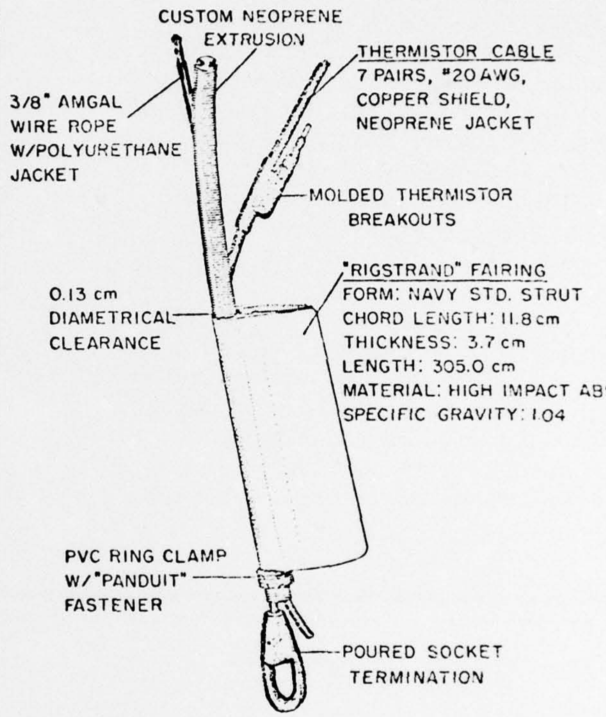
FOR FURTHER INFORMATION, CONTACT:

Hugh B. Milburn
NOAA - PMEL
3711 - 15th Avenue N.E.
Seattle, Washington 98105

Telephone: (206) 442-4546

Figure 4.

EQUA-1 CABLE FAIRING CONFIGURATION



Hugh B. Milburn has been a commissioned officer with the NOAA Corps for 10 years. He is presently assigned to the Ocean-Atmosphere Response Studies group at NOAA's Pacific Marine Environmental Laboratory in Seattle. His work includes mooring dynamics studies and engineering related to deep-ocean moorings. Milburn's education includes a BSME from California State Polytechnical University and graduate studies at the University of Washington in Ocean Engineering.

Investigators often need to know the sea-floor orientation of free-fall (or free-vehicle) instruments which remain stationary on the bottom once deployed. In such cases, it is unnecessary to continuously monitor the orientations as, for example, with the compass described by Sessions (1976). The compass described here provides the averaged orientation throughout the duration of the experiment. It requires no pressure housing, power, or external recording equipment and is both simple and cheap to construct.

film recording deep sea compass/inclinometer

The compass was developed for use with a sea-floor electric field recording system. The compass provides the bottom orientation of a tetrahedron assembled at the surface from 40-ft sections of PVC pipe. A light line tethers it to the instrument pressure housing, which releases from the apex of the tetrahedron at the conclusion of the experiment.

The idea for the compass comes from the current meter design of Avery (1968). A spot of radium powder on the point of a standard compass needle exposes the film. I have also adapted Avery's idea of filling the compass with oil to permit use at high pressure without a heavy and expensive pressure housing.

The basic enclosure (Figure 1) is a short section of core-liner tube covered with black tape to keep light out (the tape would not be necessary if an opaque material were used). I used the compass needle and suspension from a flooded Geodyne 102 current meter, but any similar compass could be easily adapted. The compass is mounted on a piece of polyethylene machined to fit the end of the tube.

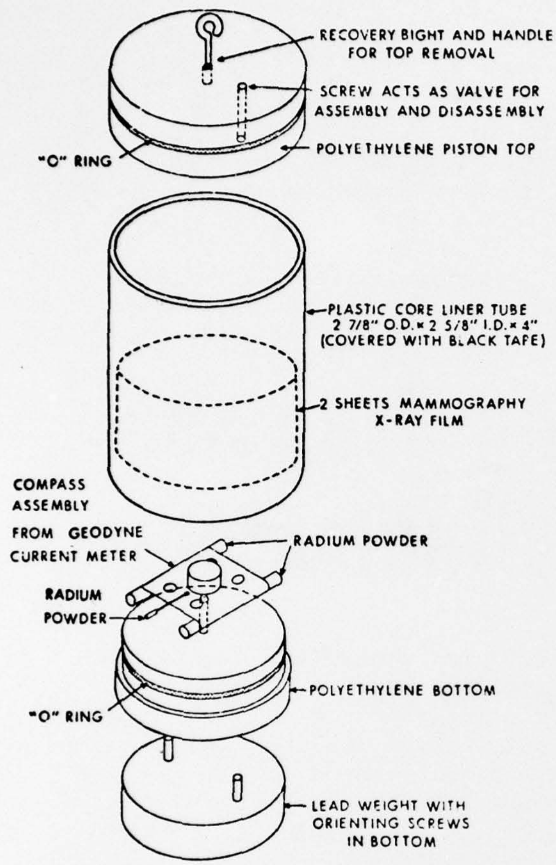


Figure 1.

COMPASS ASSEMBLY DIAGRAM. The cylinder is filled with oil or kerosene after the film is installed.

The top of the enclosure is a piston that moves to accommodate the compression of the oil at high pressure. O-ring seals are used on both ends because we have found that seawater will invade the enclosure through the smallest opening even though the pressure differential is small.

The instrument only requires a small amount of radioactive material for adequate film exposure. Radium powder is difficult to obtain, since it is no longer available to jewelers for watch and clock dials; other radionuclides that might be more easily obtained would probably work as well. The powder is mixed with a dab of epoxy, then applied to the compass point and the south-seeking ends of the two magnets, thus giving three points on the film to allow determination of both inclination and direction. I put the radium in a small lead crimp on the end of the compass needle to collimate the radiation, but this made no difference with the parameters of spacing and radiation used. The first attempt, with the film about 2-3 mm from the end of the compass needle, produced clear, well-defined points on the film. I have not experimented with other configurations.

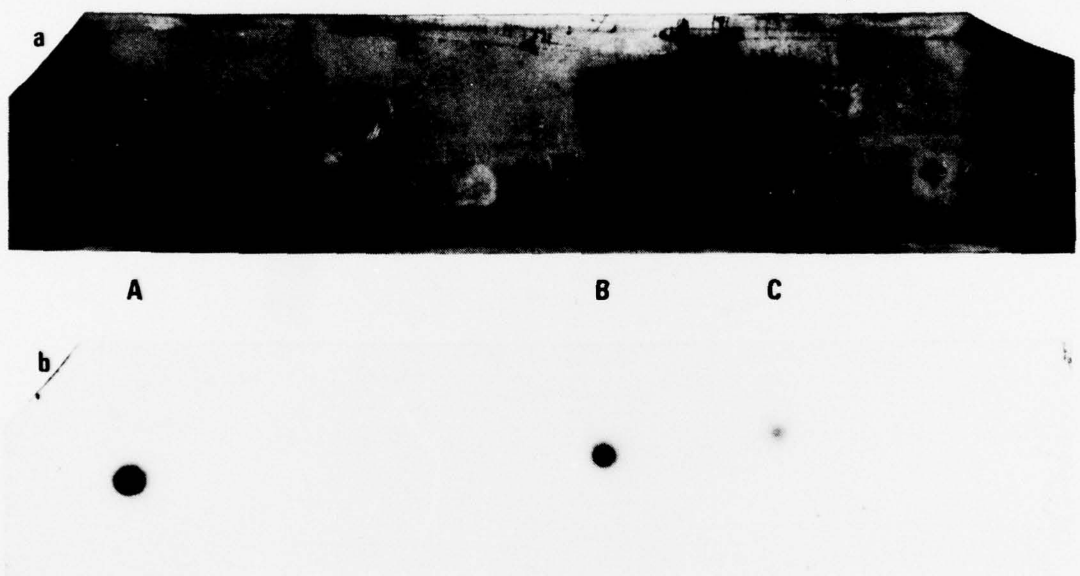
The container is filled with diesel oil or kerosene. This arrangement produces clear exposures without fogging, as long as the film is washed with detergent before development. Several types of film emulsion have worked to some extent, but mammography X-ray film, type RP/M, has given the best results. The film comes in packages of two 8 x 10-inch sheets of film double coated with different sensitivity emulsions. Using two layers of film (with four emulsion coatings) gives a very wide exposure range. This scheme produces clear, well-defined points for exposure times from two hours to two months.

Preparing the instrument for use is a straightforward procedure. In the darkroom, 45-mm x 200-mm strips cut off the two film sheets are placed in the cylinder (the inner circumference is slightly greater than 200 mm). Retaining rings made from core liner hold the film

against the cylinder at the top and bottom. A scratch on the inside of the cylinder (coinciding with a mark on the exterior black tape) provides the reference for locating the ends of the film in the dark. After the cylinder is filled with oil or kerosene, the excess fluid escapes through the screw hole in the piston top. The darkroom procedure is simple, except that care must be taken to avoid spilling the oil or kerosene, if one is to remain on speaking terms with other users of the darkroom!

A keeper magnet taped to the outside of the cylinder near the top keeps the compass needle pointed away from the film for storage and shipment. No exposure occurs after several days with this system.

The instrument was deployed for three weeks at 3000 m, producing the record shown in Figure 2. The compass balance was previously compensated for the dip at the deployment latitude, although it would be simple to subtract the dip angle from the measured inclination. I have developed a simple algorithm to calculate the direction and the inclination from the coordinates of the three points on the film.



INNER (a) AND OUTER (b) FILMS EXPOSED IN THE COMPASS (A) AND THE BACK ENDS OF THE TWO MAGNETS (B, C). The inner film (a) is more sensitive to allow recording of short term (2-6 hours) measurements. The outer layer has less sensitivity to prevent fogging during longer exposures. Both films are double coated, so four different exposure levels are available if desired.

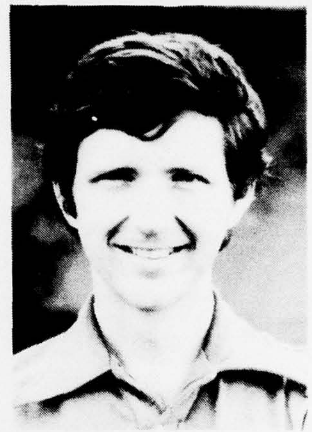
Figure 2.

Note that the same compass could also serve as an integrating direction indicator for instruments not rigidly fixed to the ocean bottom. The lack of a time scale limits its usefulness in such applications, however. I hope that the simplicity and economy of this compass design will prove helpful to other workers deploying instruments on the sea floor.

This work was supported by a grant from the National Science Foundation.

FOR FURTHER INFORMATION, CONTACT:

Thomas Daniel
University of Hawaii
Hawaii Institute of Geophysics and
Department of Oceanography
2525 Correa Road
Honolulu, Hawaii 96822



Tom Daniel is a graduate student in physical oceanography at the University of Hawaii. He is currently writing his dissertation on the use of sea-floor electric field measurements for determination of water motions.

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Sessions, M. E., 1976, "Flux-Gate Compass," *EXPOSURE*, IV (5), 5-8.

Just A Reminder!

If you have not already done so--and wish to continue receiving the EXPOSURE newsletter--please return the address update form, which was on page 11 of the last issue (Vol. 4, No. 6), by April 1977.

And, thanks to all who have responded.

Rod Mesecar, Editor

A COMPONENT-STRUCTURED SEMISPAR BUOY SYSTEM

The following article describes a modular 65-ft semispar buoy that has been used at Oregon State University, in the School of Oceanography, for moored and drifting buoy applications. Although this buoy design was initiated and used by Dr. Steven Pond* for his air/sea research needs, the buoy's modular assembly concept allows it to be easily reconfigured for other applications.[1]

Schematically, the buoy is shown in Figure 1. The major structure is composed of series 45 Rohn[2] communication tower components. The tower segments are in 10.5 ft lengths that weigh 70 lb each. Side rails for the tower segments are 1.25 inch diameter heavy wall steel tubing assembled in a 17 inch equilateral triangle design with continuous "zig zag" 7/16 inch steel cross bracing. Each tower segment is purchased with a hot dip galvanized plating that includes the inside of the side rails. The availability of the tower segments, plus a number of special tower application fixtures, from the manufacturer considerably reduces the institutional machining time and expense.

Buoy flotation is achieved with toroid-shaped floats that have a 4 ft outside diameter and a 1 ft diameter cross section. Each toroid is constructed from 2 lb/ft^3 density foam covered with 3/8 inches of chopped fiberglass with a jellcoat. One toroid will provide approximately 340 lb of net buoyancy. The distribution

*Now at University of British Columbia, Vancouver, B.C. Canada

[1]*Exposure*, Vol. 1, No. 3

[2]Rohn Manufacturing, Box 2000, Peoria, Illinois 61601

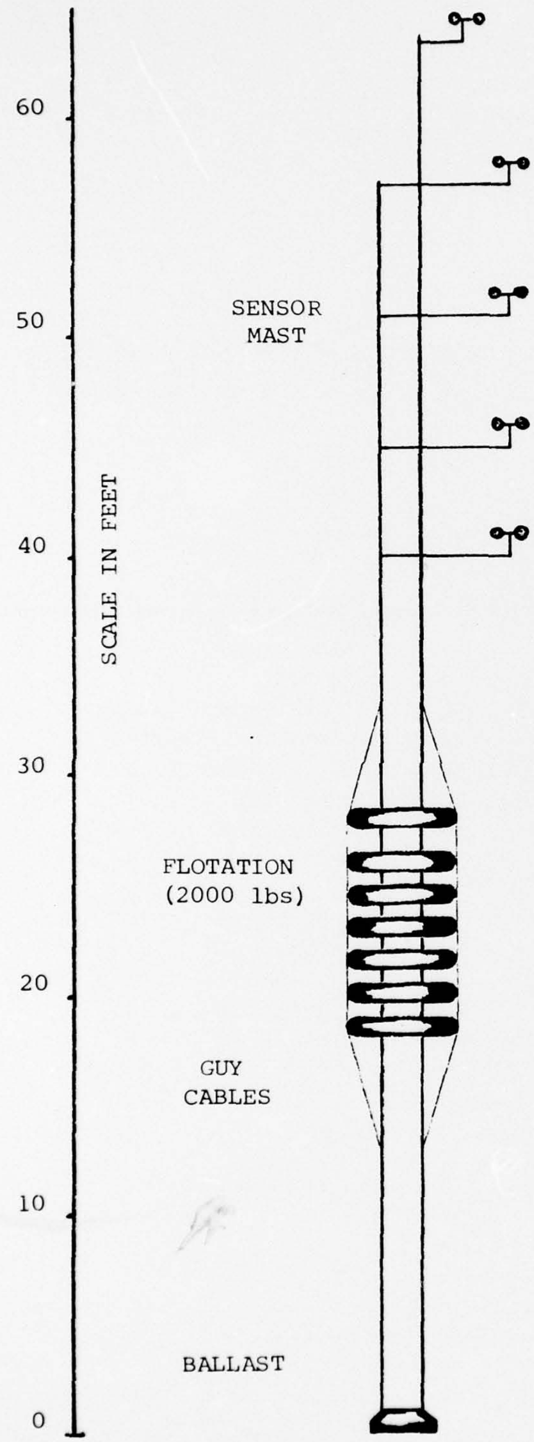

Figure 1.

and number of toroids along the tower is up to the discretion of the user to meet his application requirements. For instance, the toroids can be more widely spaced to present a ventilated figure to lateral water dynamics or the toroids can be stacked, as illustrated in Figure 1, where one is above the waterline to provide reserve buoyancy or an additional dynamic lift factor.

Each toroid has four mounting brackets equally spaced around its outer circumference. The brackets are used to couple the toroids to a section of steel channel that runs parallel to the tower section. Special adaptors have to be fabricated to mount the toroid support channels to the tower section. The mounting channels also serve as bumpers while the buoyancy section is being handled. Four guy cables have been incorporated with the toroid support channels to stiffen the tower section passing through the center of the toroids. Remaining tower sections above and below the buoyancy section do not require additional stiffening. As shown in Figure 2, the entire buoy can be lifted at the buoyancy section.

Figure 3 is a view from the bottom of the buoy. The bottom tower section is shown fitted with a bellmouth fixture that was used when the buoy was moored in shallow water applications. After the buoy was towed to a nearby mooring site, a cable was fed through the bellmouth to